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CHARACTERISTICS OF ENVIRONMENTAL TEST EQUIPMENT
AT THE Langley RESEARCH CENTER

By Sherman A. Clevenson and Ian O. MacConochie

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SUMMARY

This paper contains a brief description of major, active environmental test equipment of the Langley Research Center. Wind tunnels that provide some unusual environment are also described. A number of illustrations are shown as examples of the equipment.

INTRODUCTION

The information contained in this report is compiled in response to a recognized need for such information by the aerospace industry and other government agencies concerned with aerospace research. The Langley research division responsible for each facility is designated in this document together with the building in which the facility is located, a description of the facility, and pertinent data. Illustrations have been included to show examples of some of the equipment; these examples are not necessarily typical of the facilities within a given category.

In arranging the information in this report, an attempt has been made to group related facilities. The titles of the various categories are given in the section entitled "Index of Equipment." In certain cases the groupings are somewhat arbitrary, particularly for some of the high-temperature vacuum equipment. For instance, some of the small vacuum chambers have been listed under "Temperature-Effects Equipment" because of their relatively high-temperature capabilities.

Only those wind tunnels that provide an unusual environment are described; however, information concerning all major, active wind tunnels at the Langley Research Center is contained in reference 1. Reference 2 contains descriptions of environmental test equipment in other government installations. A listing of space chambers and associated equipment in both government and industrial establishments is given in reference 3.

USE OF FACILITIES

The primary objective of NASA facilities is to support NASA-sponsored research and development programs; however, testing time in NASA facilities may be made available upon specific request for two types of non-NASA projects:

(1) Government projects - projects that are conducted under contract with, supported by, or of vital concern to, a Government agency;

(2) Company projects - proprietary tests that may be conducted on a fee basis in certain instances, primarily in the NASA Unitary Plan wind tunnels.

It is the policy of the National Aeronautics and Space Administration in undertaking such requested testing not to compete with commercially available facilities. With the exception of the Unitary Plan wind tunnels, NASA research tunnels may be assigned to company projects only in unusual cases. Company projects are conducted in the NASA Unitary Plan wind tunnels when they are clearly in the national interest.

Prior to the submission of a formal request for tests in Langley research facilities, the interested organization should confer with the staff of the facility involved to review the nature of the required tests and the compatibility of the facility to conduct the proposed tests, and to explore the possibility of testing time being made available. Formal requests for tests in Langley facilities should be addressed to

Associate Administrator
Office of Advanced Research and Technology
National Aeronautics and Space Administration
Washington, D.C. 20546

Each request is considered upon its individual merit in the national interest. The requesting organization is advised in writing whether the tests can be undertaken. Details regarding the scheduling and conducting of the tests are negotiated directly with the Langley Research Center.

Requests from the U.S. Navy, U.S. Air Force, and U.S. Army are coordinated by two NASA allocation and priority groups, one for aircraft and missile projects and one for propulsion projects. Each group is comprised of one member each from the NASA, the Navy, the Air Force, and the Army. Requests from the military contractors are processed through the appropriate military member of the pertinent allocation and priority group.

INDEX OF EQUIPMENT

The environmental test equipment are listed by category in alphabetical order in the following table with the exception of "Miscellaneous Environmental Systems," category 19:

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ABBREVIATIONS

In the section entitled "Description of Equipment," abbreviations are used for the divisions of the Langley Research Center responsible for the equipment. These abbreviations are as follows:

AMPD	Applied Materials and Physics Division
DLD	Dynamic Loads Division
FMTD	Flight Mechanics and Technology Division
IRD	Instrument Research Division
MSD	Mechanical Services Division
SMD	Space Mechanics Division
SRD	Structures Research Division

DESCRIPTION OF EQUIPMENT

The environmental test equipment described herein are located at the Langley Research Center with the exception of several balancing machines, which are located at the Wallops Station, Wallops Island, Va. The Mechanical Services Division of Langley is responsible for this equipment.

Category 1.- Acoustical Environmental Test Equipment

15-inch-diameter unheated air jet (fig. 1), Bldg. 1221 (DLD)

Noise level, 140 to 160 dB; random frequency; elevated-temperature capability (quartz tube lamps); aerodynamic flow possible; typical test items: structural components, equipment packages, electrical boxes, heat shields, etc.

12-inch-diameter heated or unheated air jet, Bldg. 1221 (DLD)

Operational late 1965; noise level, 140 to 170 dB; random frequency; open area around jet for 7-ft distance from jet exit; typical test items: structural panels, electrical boxes, heat shields, etc.

9- by 6-foot thermal structures tunnel exhaust jet, Bldg. 1256 (DLD)

Noise level, 140 to 158 dB; random frequency; test duration, up to 60 sec; useful test area approximately 100 by 200 ft; ambient weather conditions; located outside of 9- by 6-foot tunnel.

Noise research laboratory - anechoic chamber (fig. 2), Bldg. 1218 (DLD)

Walls approximately 99-percent absorption efficiency; typical tests: sensitive equipment and psychological tests for astronauts; also used to measure discrete noise from jet engine compressors; chamber dimensions, 27 by 27 by 27 ft.

Air modulator, Bldg. 1221 (DLD)

Noise level, 150 dB; random or discrete frequencies; open area available for test approximately 1 sq ft; used for testing small structural or instrument components.

Low-frequency noise facility (fig. 3), Bldg. 1221 (DLD)

Noise level, 140 to 160 dB; random or discrete frequencies from 1 to 50 cps; test area approximately 24 ft in diameter and 20 ft in length; manned and unmanned tests of actual space vehicles, large launch structures, and buildings.

Mobile acoustics laboratory, Langley Station (DLD)

Specially equipped to measure at least 10 channels of acoustic information from 1 to 10 000 cps by means of portable microphones; used to record aircraft-engine and launch noise, sonic booms, etc.; information recorded on tape for subsequent analysis.

Large siren, Bldg. 1221 (DLD)

Noise level, 170 dB; discrete frequencies; exponential horn of 7-ft mouth diameter; frequency range, 50 to 1250 cps; test items: structural panels, equipment packages, etc.

Small siren, Bldg. 1221 (DLD)

Noise level, 170 dB; discrete frequencies; frequency range, 150 to 800 cps; test items: small structures, equipment components, etc.

Category 2.- Altitude Chamber Equipment (Life Support)

Life-support chamber (fig. 4), Bldg. 647 (AMPD)

Dimensions, diameter of 6 ft 10 in. and length of 15 ft; nominally held at pressure of 7.5 psia for space-vehicle simulated environment for vehicle crew; capabilities down to pressure of 7×10^{-2} mm Hg if desired.

Category 3.- Balancing Equipment and Spin Tables

Vertical balancing machine (fig. 5), at Wallops Station (MSD)

For balancing missile components, payloads, and live motors; capacity, 40 to 1000 lb; spin rates, up to 1000 rpm.

Horizontal balancing machine, at Wallops Station (MSD)

For balancing missile components and live motors; capacity up to 3000 lb.

Horizontal balancer, at Wallops Station (MSD)

Capacity, 200 lb and maximum specimen dimensions of 30-in. diameter and 48-in. length.

Horizontal balancer, at Wallops Station (MSD)

Capacity, 1000 lb and maximum specimen dimensions of 48-in. diameter and 8-ft length; spin rates, from 300 to 1800 rpm.

Horizontal balancer in storage at Wallops Station (MSD)

Capacity, 800 lb and maximum specimen diameter of 36 in.

Two spin rigs (portable), Bldg. 647 (MSD)

Use: test fire rocket motors while spinning

Data:

Load cell for thrust measurements from 100 to 20 000 lb

Chamber pressure and temperature measurements (32 slip rings available)

Capacity: 100 to 2600 lb

Spin rate: 0 to 1200 rpm (variable)

Power: 3 to 10 hp

Spin table (portable), Bldg. 647 (MSD)

Use: Rotate payloads for antenna pattern and acceleration tests

Capacity: 0 to 1000 lb

Spin rate: 0 to 1000 rpm (variable)

Vertical balancing machine, Bldg. 647 (MSD)

Capacity: 2000 lb at 1000-rpm spin rate

7000 lb at 230-rpm spin rate

Horizontal balancing machine, Bldg. 1225 (MSD)

Capacity: 500 lb at 2500-rpm spin rate and maximum specimen dimensions of 24-in. diameter and 48-in. length

Horizontal balancing machine, Bldg. 1225 (MSD)

Capacity: 800 lb at 1000-rpm spin rate and specimen dimensions of 48-in. diameter and 10-in. length

1000g centrifuge, Bldg. 1230 (IRD)

Diameter: 24 in.

Maximum capacity: number of g-units times specimen weight \leq 5000 g-lb, or 5-lb specimen

Maximum acceleration: 1000g at 10-in. radius

Slip rings: 18 rated at 5 amperes each

Maximum size test object: 6-in. cube

Maximum speed: 1880 rpm

Capacity of rotating pressure fitting: 0 to 500 psig

300g centrifuge, Bldg. 1230 (IRD)

Diameter: 48 in.

Maximum capacity: number of g-units times specimen weight \leq 2500 g-lb

Maximum acceleration: 300g at 32-in. radius

Slip rings: 4 rated at 20 amperes, 12 rated at 5 amperes

Maximum size test object: 12-in. cube

Maximum speed: 700 rpm

40-foot-diameter whirl table, located at landing-loads track (MSD)

Maximum g: 40

Maximum capacity: number of g-units times specimen weight \leq 16 000 g-lb

Maximum weight: 2 items of 400 lb each

Use: tests of payloads, etc.

20.5-foot-radius whirl table (fig. 6), Bldg. 1293B (DLD)

Maximum g: 100

Maximum capacity: number of g-units times specimen weight \leq 50 000 g-lb

Maximum weight: 2000 lb on one arm

Location: within 55-foot-diameter, 55-foot-high cylindrical vacuum tank
(Hydraulic shaker of 3000-lb force capability can be placed on this whirl table for combined vibration, vacuum, and sustained-acceleration studies.)

Helicopter tower, Bldg. 1231 (FMTD)

Radius of arm: 10 ft

Maximum g: 60

Maximum weight: 400-lb test item on each end

Use: tests of rocket payloads, etc.

40-foot-diameter and 20-foot-diameter rotating space-station simulator (fig. 7), Bldg. 1297 (SMD)

Used to study self-locomotion capabilities and vestibular disturbances of occupants of a rotating space station by suspending test subjects in the horizontal position, i.e., in the plane of rotation; subjects free to walk

around the perimeter (on the vertical walls) of the rotating platform; accommodates several sub-jets at a time; speeds up to 17 rpm.

Rate table, Bldg. 1230 (IRD)

Radius: 1 ft

Table capacity: 100-lb specimen

Range: continuously variable from 0.010 to 1200 deg/sec

Rate change: not to exceed 100 deg/sec

Slip rings:

8 rated at 1 ampere

8 rated at 5 amperes

Use: calibration of rate gyros

Centrifuge, Bldg. 1230 (IRD)

Diameter: 60 in.

Maximum capacity: number of g-units times specimen weight \leq 10 000 g-lb,
or 40-lb specimen

Maximum acceleration: 250g at 25-in. radius

Slip rings:

16 rated at 1 ampere

8 rated at 5 amperes

Maximum speed: 600 rpm

Use: static calibration of accelerometers

Category 4.- Emissivity Equipment

Low-temperature emissivity apparatus, Bldg. 647 (MSD)

Measures the emissivity of various materials and coatings from -50° C to 100° C; specimen wrapped around a 5/8-in.-O.D. tubing; specimen length, 36 in.

Category 5.- Fatigue Testing Machines

Three programmed variable-amplitude fatigue testing machines, Bldg. 1221 (SRD)

Axial load; programmed closed-loop servo-controlled hydraulic loading; maximum load, \pm 20 000 lb; any one of 55 presetable load levels in any arbitrary sequence; adaptation for programmed temperature under construction; cycling rate up to 420 cpm.

Two 20 000-pound axial-load machines, Bldg. 1221 (SRD)

Constant load at maximum amplitude; closed-loop servo-controlled hydraulic up to 3000 cpm; infinitely variable up to 20 000 lb

Fatigue testing machine, Bldg. 1221 (SRD)

Maximum load, \pm 20 000 lb; variable amplitude; 10 load stations with 6 specimens in series possible at each station (i.e., total of 60 specimens possible); load controlled by curve following closed-loop servo; temperature programmed with variable-time scale (i.e., same load program may be compressed to shorter time period).

Axial-load fatigue machine, Bldg. 1221 (SRD)
Random-load, 24 000-cpm hydraulic; maximum load, \pm 15 000 lb; analog input.

Fatigue testing machine, Bldg. 1221 (SRD)
Programed fatigue tests in eight steps; maximum load, 132 000 lb; maximum frequency, 4000 cpm.

Axial-load fatigue testing machine, Bldg. 1221 (SRD)
Maximum load, 100 000 lb; frequency, 1200 cpm.

Axial-load hydraulic fatigue testing machine, Bldg. 1221 (SRD)
Automatic cycling of load; maximum load, 120 000 lb; frequency, 60 cpm.

Nine 20 000-pound-capacity axial-load fatigue machines, Bldg. 1221 (SRD)
Frequency, 1800 cpm.

Nine rotating beam fatigue machines, Bldg. 1221 (SRD)
Bending capacity, 200 in-lb; frequency, 8000 cpm.

Three fatigue machines, Bldg. 1221 (SRD)
Maximum load, 25 lb; frequency, 1800 cpm.

Atmospheric corrosion fatigue testing machine, behind Bldg. 1149 (SRD)
Outdoor installation; tests 100 cantilever specimens simultaneously; frequency, 400 cpm; equipped for elevated temperatures to 550° F.

Fatigue testing machine, Bldg. 1221 (SRD)
Maximum load, 20 000 lb; frequency, 1200 cpm.

Fatigue testing machines, Bldg. 1221 (SRD)
Mean load, 1000 lb \pm 1000 lb; 1800-cpm tension-compression.

Most of the fatigue testing machines may be equipped for elevated-temperature fatigue tests. Also, a plastic material can be applied to the specimen for studies of stress distribution under polarized light.

Category 6.- Humidity Control Equipment

Controlled environment room, Bldg. 1148 (SRD)
Dimensions, 20 by 30 by 12 ft; ambient temperature and humidity ranges, 60° F to 75° F and 10 to 50 percent, for testing of filamentary- and membrane-type materials which are temperature and humidity sensitive.

Category 7.- Impulsive Loading Test Equipment

Landing-loads track (fig. 8), Bldg. 1257 (DLD)
Tests landing characteristics of airborne vehicles by means of a traveling carriage containing fixture for strut and wheel (or wheels); maximum velocity of descent of 20 ft/sec for undercarriage; maximum horizontal velocity of

200 mph on wet or dry concrete runway; instrumentation includes cameras, load-measuring devices, and pressure-measuring equipment to determine fluid pressure between tire and runway; primarily for study of skid braking qualities and wear of pneumatic tires during landing.

A water trench 6 ft deep, 10 ft wide, and 2200 ft long adjoins the concrete runway for water-landing studies, hydrofoil studies, etc.

Impact structures facility (fig. 9), Bldg. 720-B (SRD)

For study primarily of landing characteristics of reentry vehicles and booster-recovery problems; launching equipment includes slingshot (energy-source rubber shock cord) with vertical velocities up to 200 ft/sec; pendulum with vertical or horizontal velocities up to 25 ft/sec; monorail launch and towing equipment with horizontal entry velocities up to 100 ft/sec; types of landing area: 260-ft-long dry area, 200-ft-long plywood runway, 1800-ft-long water, and other surfaces, such as sand.

Drop-test machine, Bldg. 1293-B (DLD)

Rating, up to 1000-lb specimen; time duration, $2\frac{1}{2}$ to 27 milliseconds; pulse shaped by impact pellets; specimen size, $3\frac{1}{2}$ by $3\frac{1}{2}$ by $3\frac{1}{2}$ ft.

Shock calibrator, Bldg. 1230 (IRD)

Maximum test weight: 20 lb

Maximum size of test package: 6 by 6 in.

Maximum acceleration: 10 000g

Pulse duration: 0.2 millisecond to 11 milliseconds with half sine wave pulse shape

Pulse duration: 2 milliseconds to 40 milliseconds with square wave pulse shape

Use: shock calibration of accelerometers

Category 8.- Load Testing Equipment

60 000 inch-pound torsion testing machine, Bldg. 1148 (SRD)

Specimen dimensions, 5-ft length and 10-in. diameter

Combined load testing machine, Bldg. 1148 (SRD)

Combined axial, torsion, shear, and bending loads within the following capacities:

Axial:

Compression - 250 000 lb

Tension - 120 000 lb

Horizontal shear: 25 000 lb

Vertical shear: 50 000 lb

Torsion: 2 500 000 in-lb

Horizontal bending: 600 000 in-lb

Vertical bending: 3 000 000 in-lb

Specimen dimensions: up to 40 by 40 by 240 in.

Hydraulic testing machines (fig. 10), Bldg. 1148 (SRD)

All the load-testing machines may be equipped with various types of heating equipment for elevated-temperature environment. Capacities of the hydraulic testing machines are:

Maximum capacity, lb	Maximum specimen size
1 200 000	6 ft wide by 18 ft long
300 000	15 in. by 15 in. by 6 ft
120 000	8-in. diameter and 5-ft length
100 000	8-in. diameter and 4-ft length

Vertical abutment-type backstop for supporting and/or anchoring large structural test specimens, Bldg. 1148 (SRD)

Portable hydraulic jacks up to 300 000-lb capacity are available for use with this equipment. Also, available are two portable programmed loading jacks, each with a maximum capacity of 10 000 lb and a cyclic loading capability of 240 cpm.

Eleven 20 000-pound-capacity compression creep testing machines, Bldg. 1148 (SRD)

Some of these are equipped with ovens to provide temperatures up to 2500° F.

Category 9.- Lunar Environment Simulation

Lunar landing facility (fig. 11), Bldg. 1297 (SMD)

Simulates behavioral characteristics of lunar landing and flight vehicles in a lunar gravity environment (does not, however, simulate environment for pilot). Simulation is accomplished by supporting 5/6 weight of vehicle. Outdoor facility of structural steel A-frame construction with approximately 400 ft of horizontal travel, 180 feet of vertical travel, and ±25 ft of lateral travel. Maximum allowable weight of research vehicle is 20 000 lb. Maximum test duration (approximately 3 min for current vehicle) limited only by fuel supply onboard vehicle. Facility readily adaptable to other gravity levels between 0 and 1 g.

Reduced-gravity walking simulator, Bldg. 1297 (SMD)

Simulates 0 to 1 g for astronaut by suspending arms, legs, head, and torso on a series of wires approximately 150 ft long. Simulation of various g levels along the axis of the astronaut is obtained by suspending subject in various positions.

Lunar orbit and landing approach simulator, Bldg. 1220 (SMD)

Utilizes cameras and projection equipment to simulate visual experience of an astronaut during lunar approach and letdown. Simulation of the lunar surface is accomplished by utilizing lighted large-sized models of the moon and portions thereof. Simulates visual experience of pilot during letdown from an altitude of approximately 200 miles to 150 ft from the moon (completion scheduled for 1965.)

Category 10.- Meteoroid Simulation Equipment

Shock-compressed light gas gun, Bldg. 1275 (AMPD)

Velocity range, 7000 to 15 000 ft/sec; model meteoroid diameter, 0.220 in.; model meteoroid weight, 150 mg or less; maximum target diameter, 29 in.; target environment, 100 microns to 45 psi.

Accelerated reservoir light gas gun, Bldg. 1275 (AMPD)

Velocity range, 15 000 to 20 000 ft/sec; model meteoroid diameter, 0.220 in. or less; model meteoroid weight, 150 mg or less; maximum target diameter, 29 in.; target environment, 100 microns to 45 psi.

Exploding foil gun (fig. 12), Bldg. 1148 (SRD)

Pilot model of gun in operation; full-scale gun under construction; designed to extend the range of velocities attainable in the light gas guns; model meteoroid weight, 0.01 to 0.1 gram; target diameter, 2 in. to 4 in.; target environment, ambient temperature in a vacuum.

Category 11.- Radiant Heating Equipment

10 000-kilowatt radiant heating facility (fig. 13), Bldg. 1143 (SRD)

Automatic control; nine channels (nine banks of lamps possible). Heating can be programmed to specified surface temperature or thermal flux history. This unit is the power source for cylindrical, flat, or other configurations of quartz tube lamps for the testing of reentry or hypersonic structures at temperatures to approximately 3200° F.

Category 12.- Radiation Equipment

Electron accelerator, Bldg. 1283 (AMPD)

Electron energy range from 30 keV to 1.0 meV with total beam currents from 0 to 10 milliamperes. In air, samples may occupy an area of 6 in. by 30 in.

Vacuum target chambers with vacuums as low as 10^{-6} torr in combination with temperatures from -320° F to 200° F are available for targets no larger than 2 in. by 24 in. Special arrangements can be made for vacuum irradiation of targets with diameters as large as 60 in. over a temperature range of -200° F to 70° F.

Electron and positive-ion accelerator, Bldg. 1283-A (AMPD)

Electron energy range from 100 to 400 keV with total beam currents from 0 to 100 microamperes. Positive-ion energy range from 200 to 400 keV with total beam currents from 10 to 150 microamperes. Vacuum target chambers are available to accommodate samples up to 1 in. by 12 in. at temperatures from -320° F to 200° F for electron irradiation. Targets for positive-ion irradiation cannot exceed 0.5-in. diameter.

Electron and positive-ion accelerator, Bldg. 1283-A (AMPD)

Operational by mid 1965. Positive-ion energy range from 0.5 to 4.0 meV with total beam currents from 10 to 400 microamperes. Electron energy range from

1.5 to 3.0 meV with total beam currents from 0 to 100 microamperes. Vacuum target chambers are available to accommodate samples up to 1 in. by 12 in. at temperatures from -320° F to 200° F for electron irradiation. Targets for positive-ion irradiation cannot exceed 0.5-in. diameter.

Category 13.- Refrigeration Equipment (Suitable for Operation With Vacuum Units)

Helium refrigerator-liquefier, Bldg. 1236 (AMPD)

Can produce temperatures from about -300° F to -450° F in conjunction with vacuum chamber (see section 17, 150-cubic-foot space vacuum facility). Has capacity to dissipate a thermal load of 1.3 kW at -450° F and correspondingly higher loads at higher temperatures. Can produce and transfer liquid helium into portable Dewars at a rate of 80 liters per hour.

Freezer, Bldg. 1230 (IRD)

Ambient to -125° F; dimensions, 2 $\frac{1}{4}$ by 1 $\frac{1}{4}$ by 10 $\frac{1}{2}$ in.

Deep freeze, Bldg. 1230 (IRD)

Temperature range, room temperature to -120° F; dimensions, 18 by 2 $\frac{1}{4}$ by 19 in.

Category 14.- Rocket Test Equipment

Rocket test cell, Bldg. 1270 (AMPD)

Employed for static test firing of solid-propellant rockets with up to 3000-lb propellant; four test stands with force capacity of 3 to 50 000 lb and weight capacity of 1 to 10 000 lb; complete instrumentation for pressure, force, strain, and temperature data acquisition and recording; programmer used for event sequencing to 220 events.

Rocket spin test cell, Bldg. 1294 (AMPD)

Centrifuge-type apparatus employed for test firing solid-propellant rockets with up to 100-lb weight under single or simultaneously applied environments of spin and/or longitudinal acceleration fields; spin rate from 0 to 3000 rpm; longitudinal acceleration up to 30 000 g-lb; complete instrumentation for pressure, temperature, and strain data acquisition and recording.

Rocket materials jet, Bldg. 1270 (AMPD)

A small conventional liquid bipropellant rocket system utilizing hydrazine-based fuels and nitrogen tetroxide oxidizer to produce test environment for materials research; stagnation temperatures from 5000° F to 6500° F with aluminum additives; pressures from 100 to 750 psi; run time to 5 min; basic-rocket-motor dimensions, 3 $\frac{1}{2}$ -in. inside diameter and 8-in. length; throat diameter of approximately 1 in.; each propellant flow separately controllable; complete instrumentation for force, pressure, and temperature data acquisition and recording; programmer employed for event sequencing.

Category 15.- Sunlight Simulation

Carbon arc lamp (fig. 14), Bldg. 647 (AMPD)

Simulates solar spectrum. Light from carbon arc used in conjunction with vacuum equipment enters vacuum chamber through quartz glass porthole. Vacuum chamber has 10-in. diameter and is 20 in. deep. Temperature capabilities range from -200° F to 350° F. Lamp may also be used in conjunction with both the 5- by 5-foot high-vacuum system and the 5- by 10-foot thermal vacuum facility.

Solar test laboratory, Bldg. 1288 (AMPD)

The laboratory consists of a structure approximately 20 ft square in planform with a sloping door set at 37° to the horizontal. The door rolls into a special enclosure so that sunlight enters the building so as to strike a 10-ft-diameter solar collector at any time during the year from 2 hours before to 2 hours after solar noon. The main article of test equipment is a large equatorial mount which can accommodate solar collectors up to 10 ft in diameter weighing up to 200 lb. This mount can support grid test equipment and a cold-wall water-cooled cavity calorimeter.

Category 16.- Temperature-Effects Equipment

2500-kilowatt arc jet (fig. 15), Bldg. 1267 (SRD)

Test medium: arc jet nitrogen mixture (0 to 100 percent)

Test condition: open jet

Total pressure: 15 to 17 psia

Total temperature: 7200° R

Enthalpy: up to 3550 Btu/lb

Mach number: up to 1.7 (corresponds to 5500 ft/sec) at maximum temperature and pressure

Running time: continuous

Density: 0.0045 to 0.007 lb/ft³

Dynamic pressure: 0 to 4000 psfa

A similar facility is also operational in Bldg. 1148.

20-inch hypersonic arc-heated tunnel, Bldg. 1275 (AMPD)

Arc power, mW	1.8	1.95	2.06
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Total pressure, psia	76	157	389
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Throat diameter, in.	0.538	0.538	0.538
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Mach number	6 or 10	6 or 10	6 or 10
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Stagnation-point heating

rate on 2-in.-diam hemis-

sphere, Btu/ft²-sec 170 or 66 (approx) Not measured Not measured

Total enthalpy, Btu/lb	4672	2750	1602
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Model diameters up to 2 in. can be accommodated at Mach 6 and up to 4 in. at Mach 10. Run times are 3 min at Mach 6 and 1 min at Mach 10. Stagnation temperatures from 4000° R to 8000° R can be achieved at particular test conditions.

12-inch hypersonic ceramic-heated tunnel, Bldg. 1274 (AMPD)

Stagnation temperature, °R	2400 to 3700
Stagnation pressure, psia	65 to 600
Mach number	Approx 13
Stagnation-point heating rate on 2-in.-diam hemisphere, Btu/ft ² -sec	4 to 16
Maximum diam of hemisphere-nose model, in.	3.75
Reynolds number per foot	17 000 to 230 000
Velocity, ft/sec	5350 to 6600
Run time, sec	30 to 60
Dynamic pressure, lb/ft ²	5 to 33

11-inch ceramic-heated tunnel, Bldg. 1263 (AMPD)

Stagnation temperature, °R	2400 to 4000	2400 to 4000	2400 to 4000
Stagnation pressure, psia	115	800 to 1200	700 to 1200
Mach number	2	4	6
Nozzle exit diameter, in.	0.75	4.0	10.6
Throat size, in.	0.50	1.22	1.22
Stagnation-point heating rate on 2-in.-diam hemis- phere, Btu/ft ² -sec	84 to 223	120 to 366	45 to 150
Maximum diam of hemisphere- nose model, in.	1.75	2	4
Reynolds number per foot	2.2×10^6 to 5.2×10^6	3.6×10^6 to 13.6×10^6	0.8×10^6 to 4.5×10^6
Velocity, ft/sec	3300 to 4680	4400 to 6380	4700 to 6900
Run time, sec	600	60	60

Arc-heated materials jet, Bldg. 1273 (AMPD)

Mach number	2
Stagnation pressure, psia	165
Stagnation enthalpy, Btu/lb	1300
Stagnation-point heating rate on 3/8-in.-diam hemisphere, Btu/ft ² -sec	1000
Hemisphere-model diam, in.	Up to 0.5
Run time, sec	180
Stagnation temperature, °R	4000 to 6000

600° F furnace, Bldg. 1148

Dimensions, 37 by 37 by 24 in.

Twelve miscellaneous small furnaces, Bldg. 1148

Temperature capacities: up to 3000° F for continuous service

9- by 6-foot thermal structures tunnel, Bldg. 1256 (SRD)

Test medium	Air	Air	Air	Air
Total pressure, psia	50	50	200	200
Total temperature, °R	760	1120	760	1120
Enthalpy, Btu/lb	190	285	190	285
Test-section dimensions, in.	72×105	72×105	72×105	72×105
Mach number	3	3	3	3

10-megawatt arc tunnel, Bldg. 1267 (SRD)

Type of heater: ac water-cooled copper electrodes

Test medium: air

Maximum power: 10 000 kW (3500 kW to arc head)

Nozzle type: supersonic, conical

Principal uses: ablation, thermal-protection models

Data recording:

40 channels plus 1 channel for power

Automatic data processing available

Model mounting: sting-retractable

Test frequency: 2 per day

Settling chamber:

Total pressure, psia	75	345
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Total temperature, °R	7350	2160
---------------------------------	------	------

Enthalpy, Btu/lb	3000	550
----------------------------	------	-----

Test section:

Nozzle-throat diameter, in.	0.620	0.620
-------------------------------------	-------	-------

Test-section diameter, in.	6.30	6.30
------------------------------------	------	------

Maximum model diameter, in.	3.0	3.0
-------------------------------------	-----	-----

Mach number	5.1	6.85
-----------------------	-----	------

Velocity, ft/sec	11 000	5100
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Static pressure, psia	0.043	0.09
---------------------------------	-------	------

Static temperature, °R	2100	225
----------------------------------	------	-----

Static density, lb/ft ³	5.7 × 10 ⁻⁵	107 × 10 ⁻⁵
--	------------------------	------------------------

Static density altitude, ft	165 000	99 600
---------------------------------------	---------	--------

Dynamic pressure, psf	95	462
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Total pressure behind shock, psia	1.25	4.75
---	------	------

Reynolds number per foot	0.063 × 10 ⁶	0.46 × 10 ⁶
------------------------------------	-------------------------	------------------------

Heating rate on 2-in.-diam hemisphere, Btu/ft ² -sec	112	30
---	-----	----

Running time, sec	600	600
-----------------------------	-----	-----

Weight flow, lb/sec	0.127	1.12
-------------------------------	-------	------

Exhaust: through diffuser and heat exchanger into vacuum tank at minimum pressure of approximately 1 mm Hg.

High-enthalpy direct-current plasma jet, Bldg. 1267 (SRD)

Type of heater: direct-current constricted arc with tungsten-copper electrodes

Test medium: nitrogen with oxygen and/or carbon dioxide

Maximum power: 2 megawatts

Nozzle type: subsonic

Principal uses: materials testing; plasma diagnostics

Data recording: high-speed digital; oscillograph

Model mounting: water-cooled sting

Test frequency: 6 per day

Settling chamber:

Total pressure, psia	17.3	17.7
--------------------------------	------	------

Total temperature, °R	15 000	8300
---------------------------------	--------	------

Enthalpy, Btu/lb	17 500	4000
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Test section:

Nozzle-throat diameter, in.	1	1
Test-section diameter, in.	1	1
Mach number	0.48	0.54
Velocity, ft/sec	3880	2240
Static pressure, psia	14.7	14.7
Static temperature, °R	14 700	8200
Static density, lb/ft ³	1.4×10^{-3}	4×10^{-3}
Static-density altitude, ft	93 800	72 000
Dynamic pressure, psf	330	320
Reynolds number per foot	0.44×10^{-6}	0.085×10^{-6}
Heating rate on 2-in.-diam hemis-		
phere, Btu/ft ² -sec	2080	475
Running time	Continuous	Continuous
Weight flow, lb/sec	0.03	0.06
Exhaust: atmospheric		

8-foot high-temperature structures tunnel, Bldg. 1265 (SRD)

Test medium: methane air combustion gases

Total pressure, psia	200	200	4000	4000
Total temperature, °R	2500	4500	2500	4500
Enthalpy, Btu/lb	730	1400	730	1400
Test-section diam, in.	96	96	96	96
Mach number	7.7	6.8	7.7	6.8
Velocity, ft/sec	5360	7930	5360	7930
Static density, lb/ft ³	1.99×10^4	1.1×10^4	39×10^4	22×10^4
Dynamic pressure, psf	103.5	103.5	2075	2075
Running time, sec	210	220	30	42

7-inch Mach 7 pilot tunnel, Bldg. 1263 (SRD)

Test medium: methane air combustion gases

Total pressure, psia	400	400	2500	2500
Total temperature, °R	2500	3800	2500	3800
Enthalpy, Btu/lb	700	1140	700	1140
Test-section diam, in.	7.5	7.5	7.5	7.5
Mach number	7.4	7.0	7.4	7.0
Velocity, ft/sec	5360	7300	5360	7300
Static density, lb/ft ³	5.73×10^4	3.76×10^4	35.8×10^4	23.5×10^4
Dynamic pressure, psf	288	288	1800	1800
Running time, sec	70	70	15	15

3000° F vacuum furnace, Bldg. 1148 (SRD)

Dimensions, 3 ft in diameter and 4 ft in height; temperature range, 75° F to 3000° F; tantalum foil resistance heaters; high-temperature and vacuum exposure of materials; used to study brazing, diffusion, bonding, sintering, and heat transfer; maximum specimen diameter, 6 in.

3000° F furnace, Bldg. 1230 (IRD)

Any atmosphere; maximum dimensions of test object, $1\frac{1}{2}$ - in. diameter and 4-in. length.

Furnace, Bldg. 1230 (IRD)

Maximum temperature, 2000° F; maximum dimensions of test object, 2 by 2 by 2 ft.

Furnace, muffle, Bldg. 1230 (IRD)

Maximum temperature, 2000° F; test-chamber dimensions, 6 by 11 by 18 in.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 800° F; test-chamber dimensions, 23 by 12 by 19 in.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 650° F; test-chamber dimensions, 4 by 4 by 6 ft.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 600° F; test-chamber dimensions, 24 by 36 by 21 in.

Oven, Bldg. 1230 (IRD)

Temperature range, -100° F to 600° F; test-chamber dimensions, 25 by $6\frac{1}{2}$ by $7\frac{3}{4}$ in.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 500° F; test-chamber dimensions, 19 by 19 by 19 in.; auxiliary vacuum bell jar with 6-in. diameter and 6-in. height.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 450° F; test-chamber dimensions, 1 by 1 by 1 ft.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 360° F; test-chamber dimensions, 19 by 19 by 19 in.

Oven, Bldg. 1230 (IRD)

Temperature range, ambient to 200° F; test-chamber dimensions, 4 by 4 by 4 in.

Furnace, Bldg. 1267 (SRD)

Test-chamber dimensions, 10-in. diameter and 15-in. height; maximum temperature, 2700° F.

Category 17.- Vacuum Chambers

60-foot vacuum sphere (fig. 16), Bldg. 1295 (MSD)

Originally used in development of Explorer IX, Echo I, and Echo II; now for general use; door diameter, 12 ft; pressure, 2×10^{-4} mm Hg; equipment, high-speed cameras; building 40 by 100 ft for instrumentation, working area, etc.

60-foot spherical free-body dynamics facility, Bldg. 1293-A (AMPD)

This facility is a spacecraft orientation and guidance-control-systems testing facility. Provisions are made for both solar and planetary

simulation. The spacecraft is supported on an air-bearing providing a nearly frictionless support. The solar simulator provides a 30-in.-diameter beam which rotates at sidereal velocity about an axis parallel to the spin axis of the earth. The planet simulator rotates about this same axis at rates from sidereal velocity to 1 rpm. The vacuum environment provided is sufficient to render negligible aerodynamic drag. No attempt at cold-wall techniques is made, but rather a thermal differential technique is employed for infrared planet sensing systems. Provision is made to acquire data from research models and spacecraft by FM-FM telemetry. Nine analog and ten digital channels are available with real-time readout. The facility is scheduled to be operational in late 1965.

55-foot-diameter, 55-foot-high cylindrical vacuum tank (fig. 6),
Bldg. 1293 (DLD)

Pressure, 4×10^{-2} mm Hg with mechanical pumps, 1×10^{-4} mm Hg with diffusion pumps; door dimensions, 20 by 20 ft; contains whirl table and vibration equipment to study the behavior of space structures under certain combined environments.

41-foot-diameter vacuum sphere, Bldg. 1295 (MSD)

Pressure, 5 mm Hg; used for booster-separation tests and tests of inflatable structures; 4-ft-diameter door.

7-foot-long, 6-foot-diameter chamber, Bldg. 1293-B (DLD)

6-ft-diameter door. Will be used primarily for combined environmental testing with vacuum chamber (pressure, 1×10^{-8} mm Hg), a 2000-lb force shaker, and temperature range of -320° F to 1400° F.

5-foot-diameter, 10-foot-long thermal vacuum facility, Bldg. 647 (AMPD)

Stainless-steel cylinder 5 ft in diameter and 10 ft in length. Pressures below 1×10^{-6} torr can be achieved. Pressure instrumentation includes an absolute pressure gage, a thermocouple gage, and an ionization gage. The pumping system consists of a 16-in., 10 000 liters/sec diffusion pump backed by a roughing pump. A temperature range from -320° F to 600° F can be obtained using liquid-nitrogen panels and quartz-lamp heaters. The cylinder has six viewing ports and a glass door. The door can be used with a 15-kW arc searchlight solar beam simulator. Facility may be used for cooling and heating payloads.

5-foot-diameter, 5-foot-long vacuum system, Bldg. 647 (AMPD)

The working volume is a horizontal cylinder 5 ft in diameter and 5 ft in length. It is lined with liquid-nitrogen-cooled surfaces that completely baffle the working volume from the ambient thermal energy. The primary access to the working volume is through the 5-ft-diameter door located on one end of the chamber. Other access is provided through a 10-in.-diameter port in the door and three other 10-in.-diameter ports located 90° apart on the cylinder. Each port contains a cooled iris for adjusting the opening to any desired size up to 10 in. The chamber is capable of obtaining vacuum levels to 5×10^{-7} torr. A subassembly is available for installation inside this chamber, that will permit measurements of radiation emittance values at

temperatures up to 100° C. The total hemispherical emittance can be determined for any opaque thin film or coating that can be bonded to the outside surface of a 5/8-in.-diameter tube. Facility may be used for cooling and heating payloads.

$2\frac{1}{2}$ -foot-diameter, 5-foot-long vacuum chamber, Bldg. 1221 (SRD)

Pressure, 10^{-6} mm Hg; temperature range, -300° F to 1000° F; may be used for cooling and heating payloads.

Dynamic and thermoelasticity altitude chamber, Bldg. 1148 (SRD)

Dimensions, 2.5 ft in diameter and 4 ft in length; pressure, 1×10^{-9} mm Hg; for structural research; ambient temperature; 2.5-ft-diameter opening.

Vibration and vacuum test chamber, Bldg. 1148 (SRD)

Dimensions, 2.5 ft in diameter and 4 ft in length; pressure, 1×10^{-8} mm Hg; mercury-xenon lamp for heating; liquid-nitrogen cold walls for cooling; used for payload performance tests and emissivity and conductivity research; 2.5-ft-diameter opening.

8-foot-diameter, 8-foot-long seals test chamber, Bldg. 647 (AMPD)

Stainless-steel cylinder 8 ft in diameter and 8 ft in length. Pressure below 1×10^{-6} torr can be achieved as measured by an ionization gage. Pumping system consists of a 32-in. oil diffusion pump backed by a roughing pump. The chamber contains a docking port and an air lock flange with a diameter of 4 ft. The chamber is used to test air locks and air-lock seals.

Rotating vacuum seals chamber, Bldg. 647 (AMPD)

Cylindrical chamber 4 ft in diameter and 3 ft in length. Pressures below 1×10^{-7} torr can be achieved. Tests can be performed on rotating vacuum seals with diameters up to 36 in. Shaft drag is measured by strain gages on rotating shaft operated at variable speeds. Leakage at seal is measured by a helium mass spectrometer.

150-cubic-foot space vacuum facility (fig. 17), Bldg. 1236 (AMPD)

The primary working volume of 150 cu ft is enclosed by a cylindrical liquid-helium-cooled wall about $5\frac{1}{2}$ ft in diameter and 7 ft in length. If desired, the wall can be removed to leave a 300-cu-ft working volume enclosed by a cylindrical liquid-nitrogen-cooled inner chamber about $6\frac{1}{2}$ ft in diameter and 8 ft in length. The inner chamber is also removable from the outer chamber and, when removed, leaves a 400-cu-ft working chamber about $7\frac{1}{2}$ ft in diameter and 12 ft in length which operates at ambient temperature. Vacuum levels in the test volume from about 10^{-4} torr to less than 5×10^{-10} torr can be achieved depending on the inner-chamber configuration. The inner-chamber walls can dissipate heat loads ranging from 1.3 kW, while maintaining wall temperatures at -450° F; to 10 kW, while maintaining wall temperatures at -300° F. Radiant heaters can be mounted in the chamber to give a heat flux level to about $2\frac{1}{2}$ earth suns.

20-cubic-foot ultra high vacuum chamber, Bldg. 1236 (AMPD)

The chamber is a horizontal cylinder with full-opening, full-diameter doors on both ends. The internal dimensions of the chamber are about 2.5 ft in diameter and 3.5 ft in length; the internal volume is about 20 cu ft. There are nine 5-in. portholes on the chamber in addition to the two doors. The chamber is capable of vacuum levels from about 10^{-4} torr to less than 2×10^{-11} torr.

100-cubic-foot utility vacuum chamber, Bldg. 1293-A (AMPD)

Cylinder 5 ft in length and 5 ft in diameter. Pressures to 5×10^{-2} torr can be achieved in the system. Access to the test volume is provided through a 30-in.-diameter door and a 6-in.-diameter porthole in the door and through three additional 6-in.-diameter portholes spaced 90° apart around the cylinder.

Space environmental chamber, Bldg. 647 (MSD)

Dimensions, 8 ft in diameter and 15 ft in length; pressure, 1×10^{-6} mm Hg; temperature range, -300° F to 400° F; used to test performance of large payloads (used for tests of micrometeorite payload).

Ultrahigh vacuum bell jar, Bldg. 647 (MSD)

Dimensions, 30-in.-length and 18-in.-diameter liquid-nitrogen cold-wall panels; pressure, 10^{-11} torr; temperature range, -320° F to 400° F; strip heaters (electrical resistance); for testing of organic material degradation characteristics.

There are a number of other vacuum chambers of smaller sizes available in addition to those listed herein.

Category 18.- Vibration and Shaker Equipment

Vibration exciter system, Bldg. 1230 (IRD)

Frequency range: 5 to 10 000 cps

Maximum force: 300 lb

Displacement range: 0.5 in. peak to peak

Maximum bare table acceleration: 100g

Type of control: constant amplitude, velocity, or acceleration

Type of vibration: sine wave only

Use: for the dynamic calibration of accelerometers and vibration pickups

Vibration exciter, Bldg. 1230 (IRD)

Frequency range: 5 to 2700 cps

Maximum force: 10 000 lb

Displacement range: 1 in. peak to peak

Maximum bare table acceleration: 98g

Type of control: constant amplitude, velocity, or acceleration; or
constant amplitude to constant acceleration

Type of vibration: sine, random, or combined sine and random

Shaker, Bldg. 1293-B (DLD)

Frequency range: 5 to 500 cps

Maximum force: 650 lb

Displacement range: 1 in. peak to peak

Maximum bare table acceleration: 57.5g

Type of control: manual

Type of vibration: sine only

Three air shakers, Bldg. 1229 (DLD)

Manual operation; no physical contact of shaker with test specimen; sinusoidal excitation; maximum force, 7 lb; frequency range, 1/2 to 1000 cps.

Two electromagnetic shakers (fig. 18), Bldg. 1293-B (DLD)

Sinusoidal excitation; manual control; maximum force, 10 lb; frequency range, 5 to 2000 cps.

Two electromagnetic shakers, Bldg. 1293-B (DLD)

Sinusoidal excitation; maximum force, 25 lb; frequency range, 5 to 20 000 cps.

Four electromagnetic shakers, Bldg. 1293-B (DLD)

Sinusoidal excitation; maximum force, 50 lb; frequency range, 5 to 2000 cps.

Hydraulic shaker, Bldg. 1293-B (DLD)

Manual control; sinusoidal excitation; maximum force, 3000 lb; frequency range, 0 to 800 cps. (See fig. 6 for combined environmental use.)

Electromagnetic shaker, Bldg. 1293-B (DLD)

Automatic control; sinusoidal and random excitation; maximum force, 2000 lb; frequency range, 5 to 5000 cps.

Electromagnetic shaker (fig. 19), Bldg. 1293-B (DLD)

Sinusoidal and random excitation; maximum force, 28 000 lb; frequency range, 5 to 2000 cps.

Category 19.- Miscellaneous Environmental Systems

Multimode gyro turntable system, Bldg. 1298 (IRD)

Position mode -

Continuous range: 360°

Accuracy: ±2 arc-seconds

Resolution and repeatability: ±1 arc-second

Rate mode -

Range: 1, 2, 4, 5, 10, 20, 25, 50, 100, and 200 times the earth rate of rotation ($\approx 15^\circ$ per hour)

Accuracy:

0.1 percent short term (15 sec)

0.0005 percent long term (15 min or longer)

Vehicle simulation system, Bldg. 1298 (IRD)
Three-axis, air-bearing inertial simulator; controllable magnetic field;
load capability, 500 lb
Inertial simulator -
Angular range:
 360° continuous about roll axis
 ±20° about pitch and yaw axes
Inertia:
 Roll axis - adjustable, 2 slug-ft² to 50 slug-ft²
 Pitch and yaw - adjustable, 6 slug-ft² to 150 slug-ft²
Spinning-mode range: 0 to 10 rps
Readout:
 Pitch and yaw - 2 arc-minutes
 Roll - reference pulse
Magnetic-field generator -
Field strength: 0 to 1.25 gauss, any direction
Accuracy: ±5 gamma
Resolution: ±2 gamma

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., May 13, 1965.

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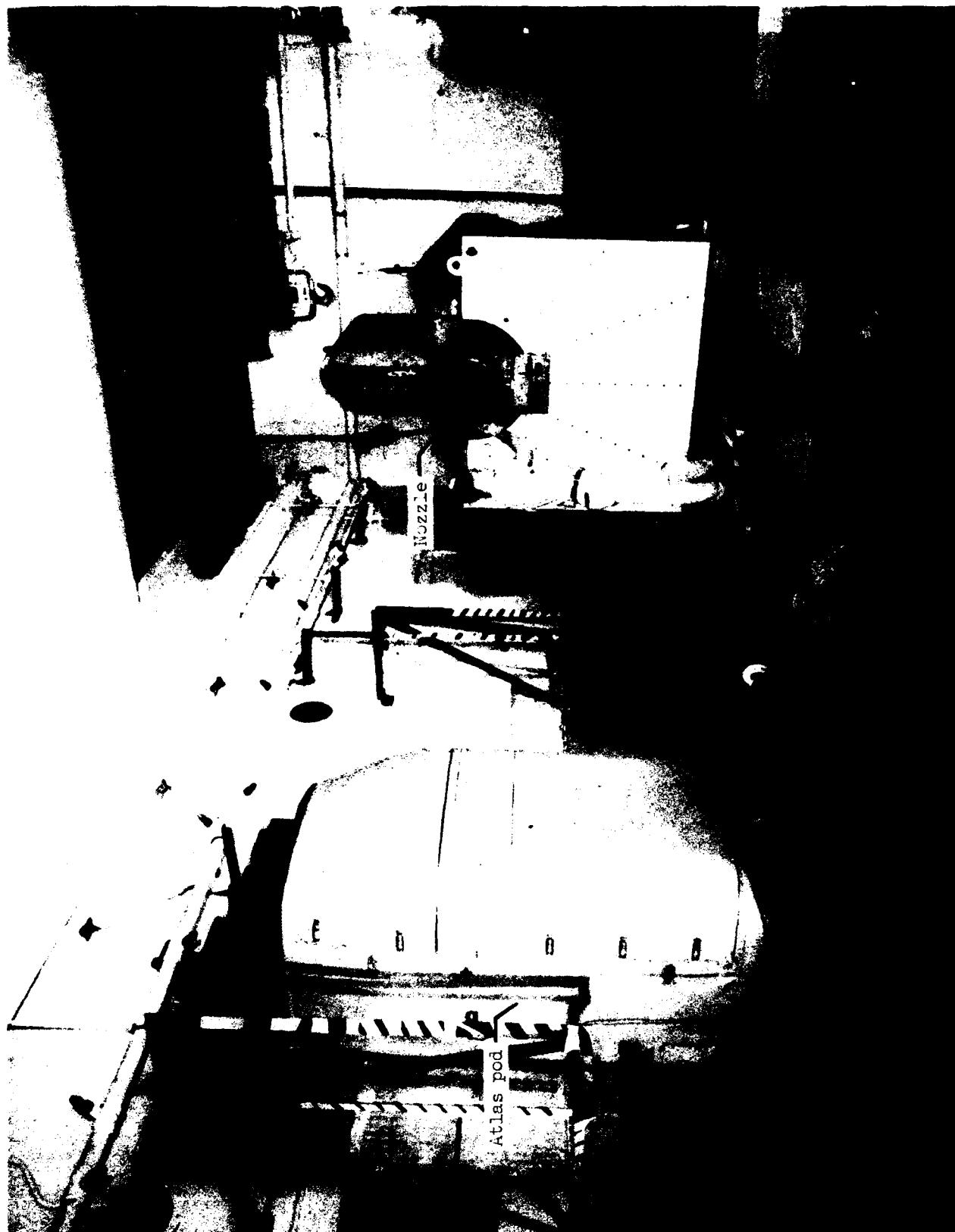
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Figure 1.- 15-inch-diameter unheated air jet with Atlas pod in testing position.



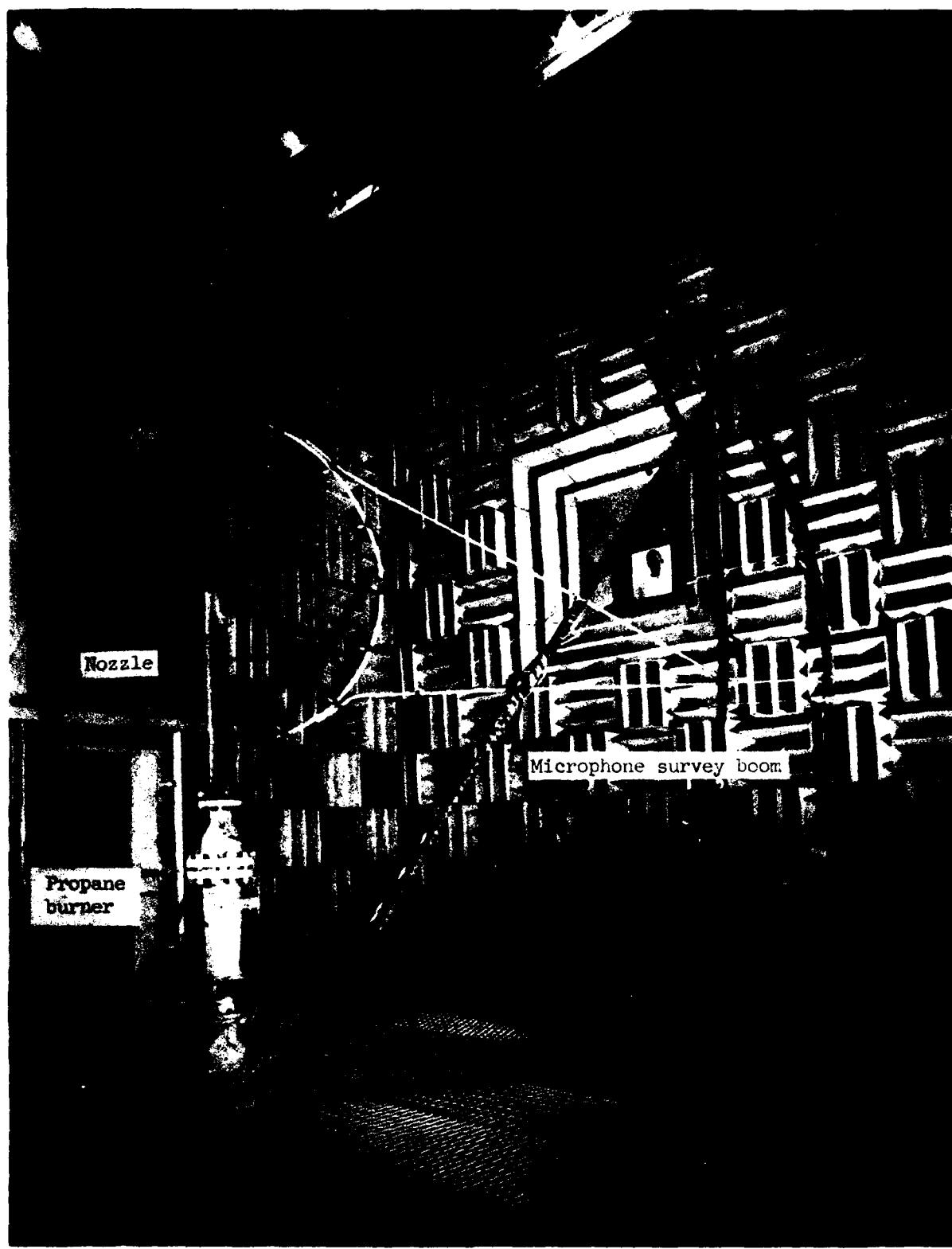


Figure 2.- Anechoic chamber of the noise research laboratory. L-62-3924.1

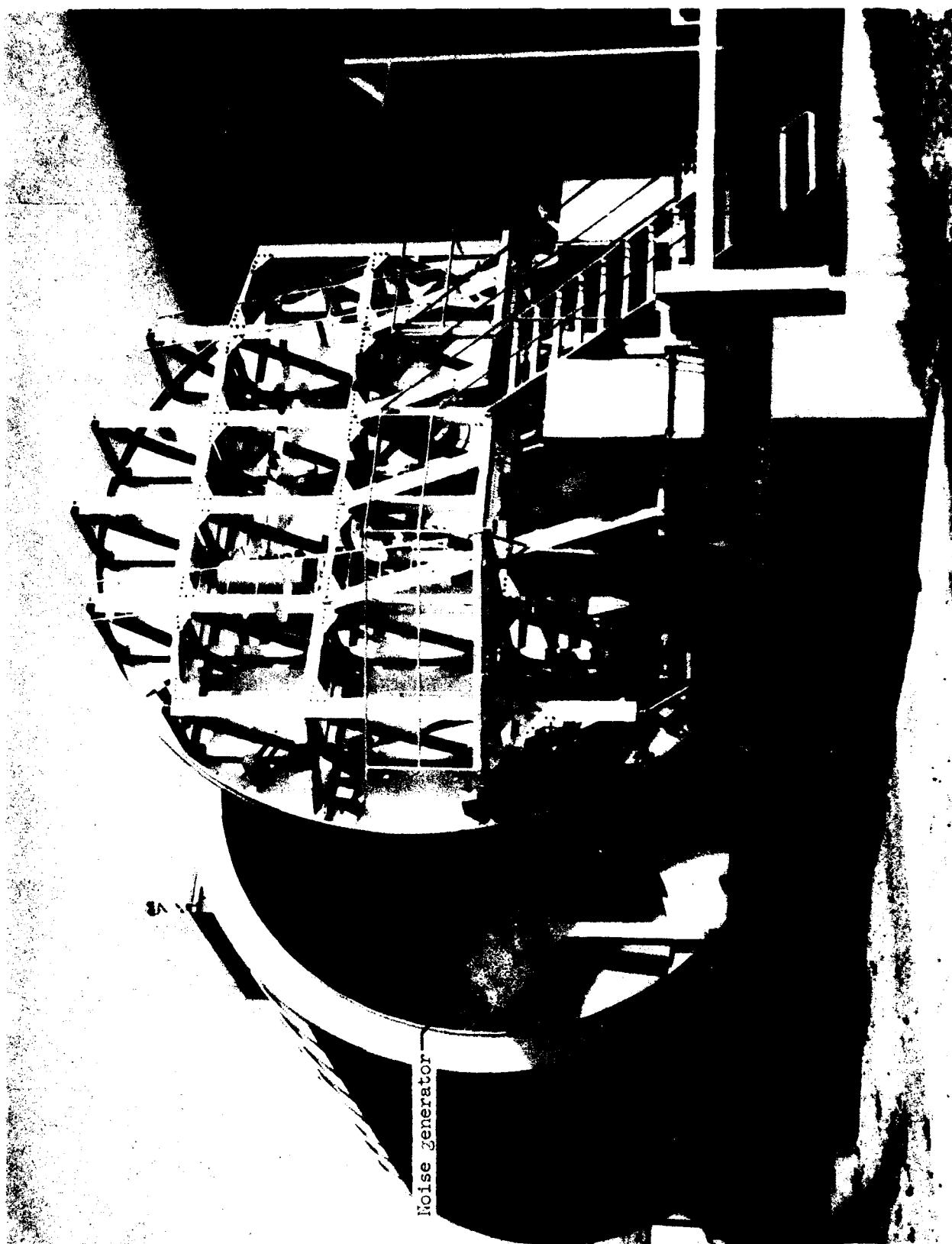


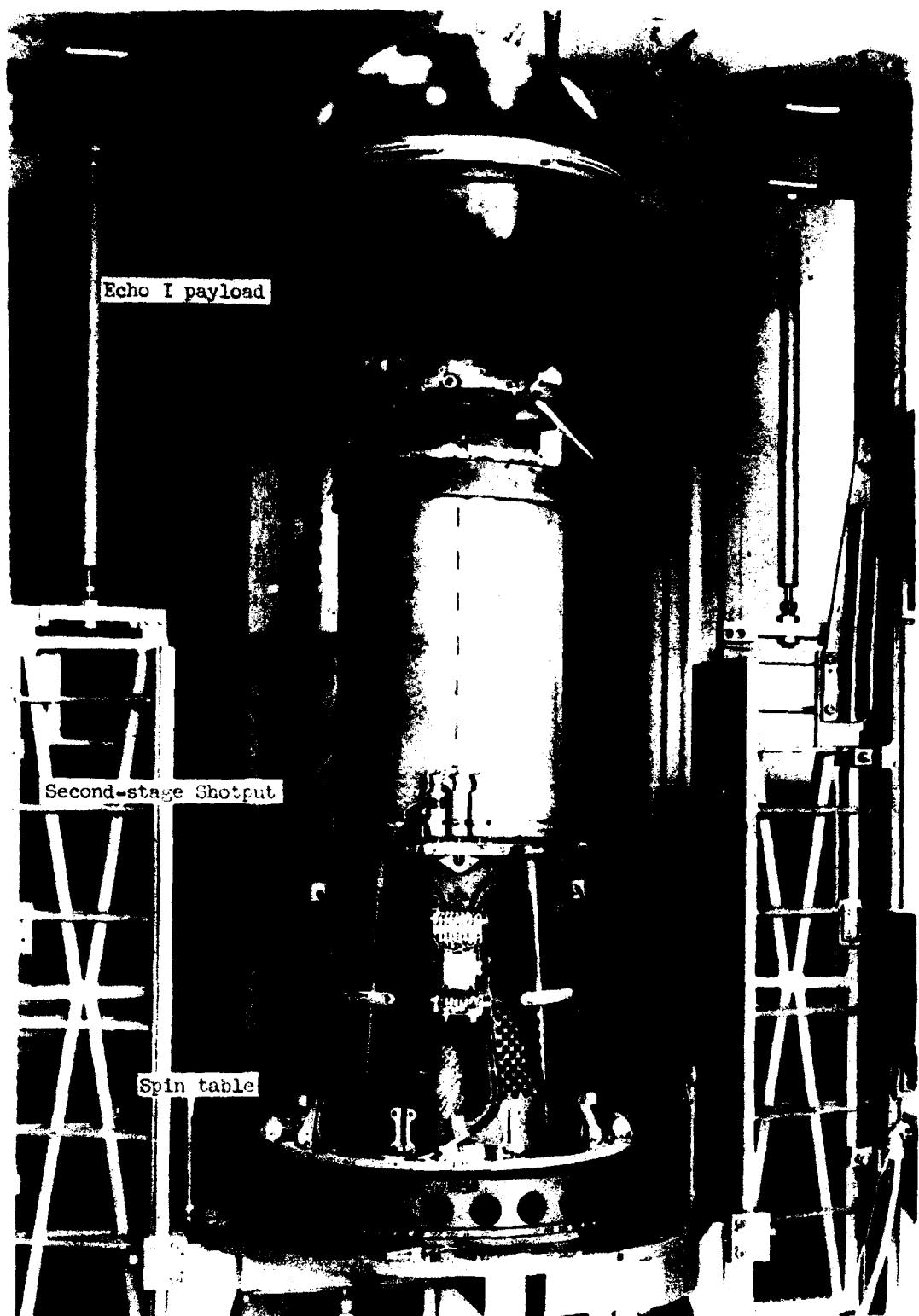
Figure 3.- Low-frequency noise facility with movable door pulled back.

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Figure 4.- Life-support chamber.





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Figure 5.- Second stage of Shotput and spin table assembly mounted on the vertical balancing machine at Wallops Station.

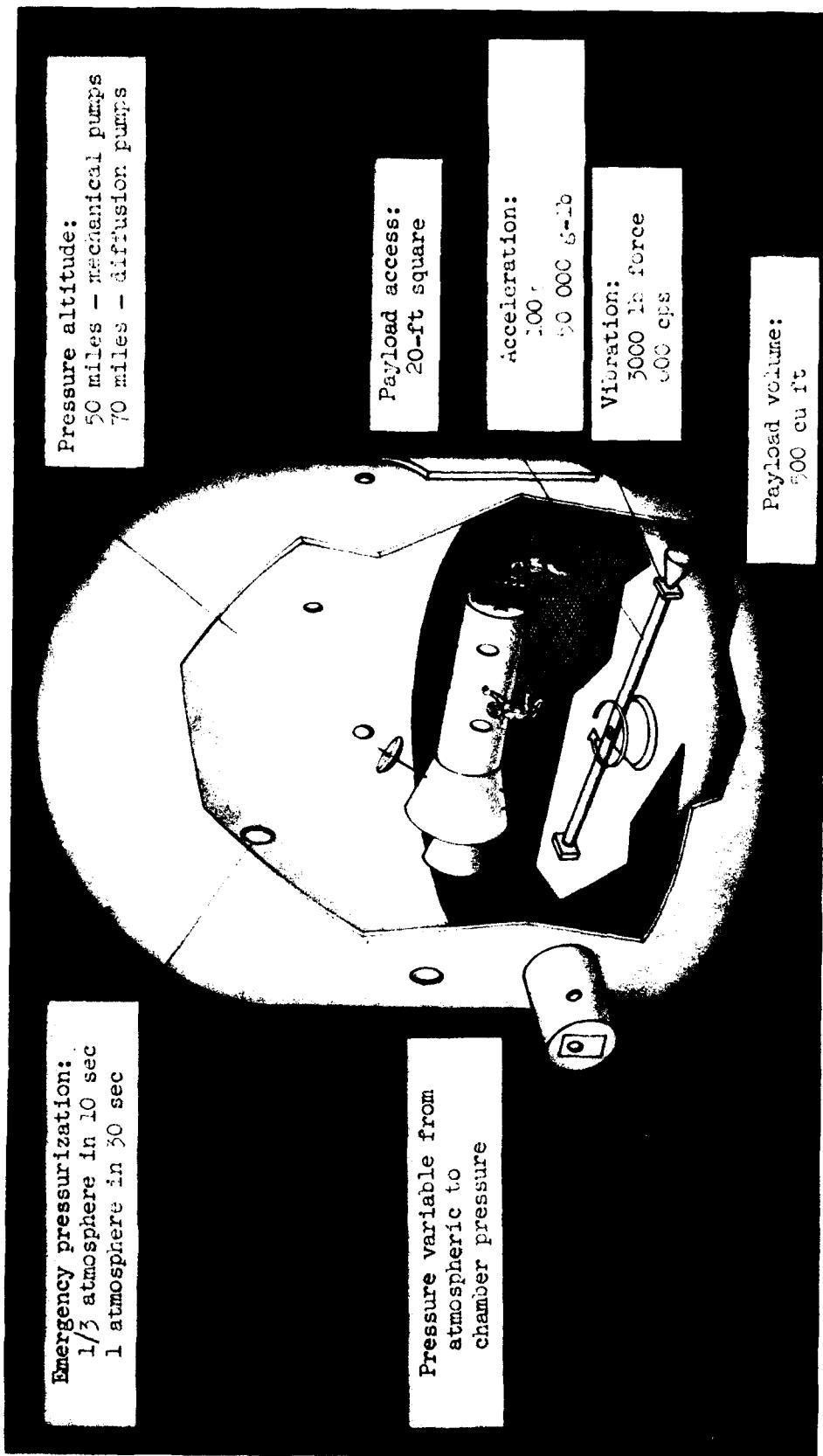


Figure 6.- 20.5-foot-radius whirl table equipped with a 3000-lb shaker located in 55-foot-diameter, 55-foot-high cylindrical vacuum tank.

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L-64-10098.1

Figure 7.- 40-foot-diameter and 20-foot-diameter rotating space-station simulator.



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Figure 8.- Landing-loads track.

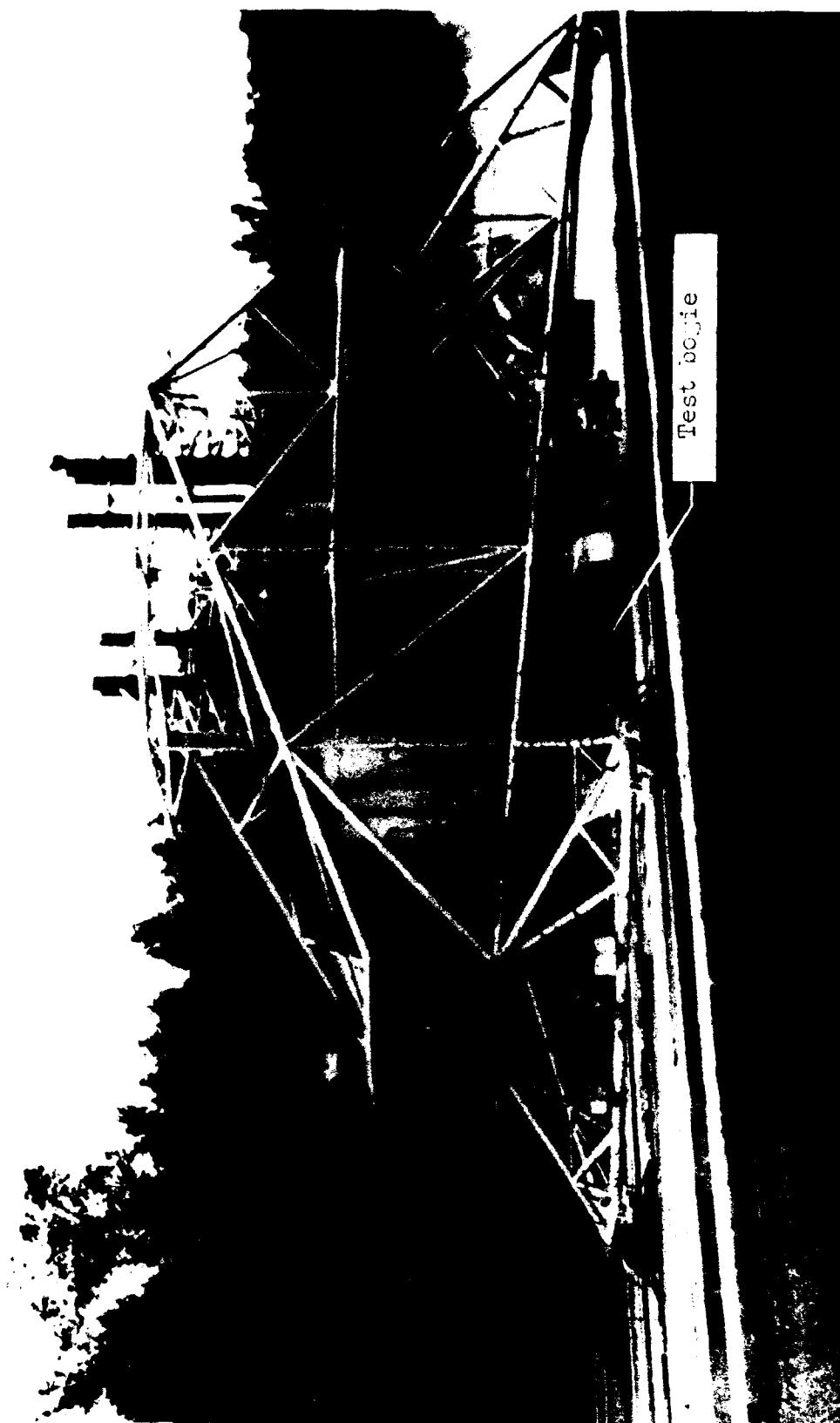
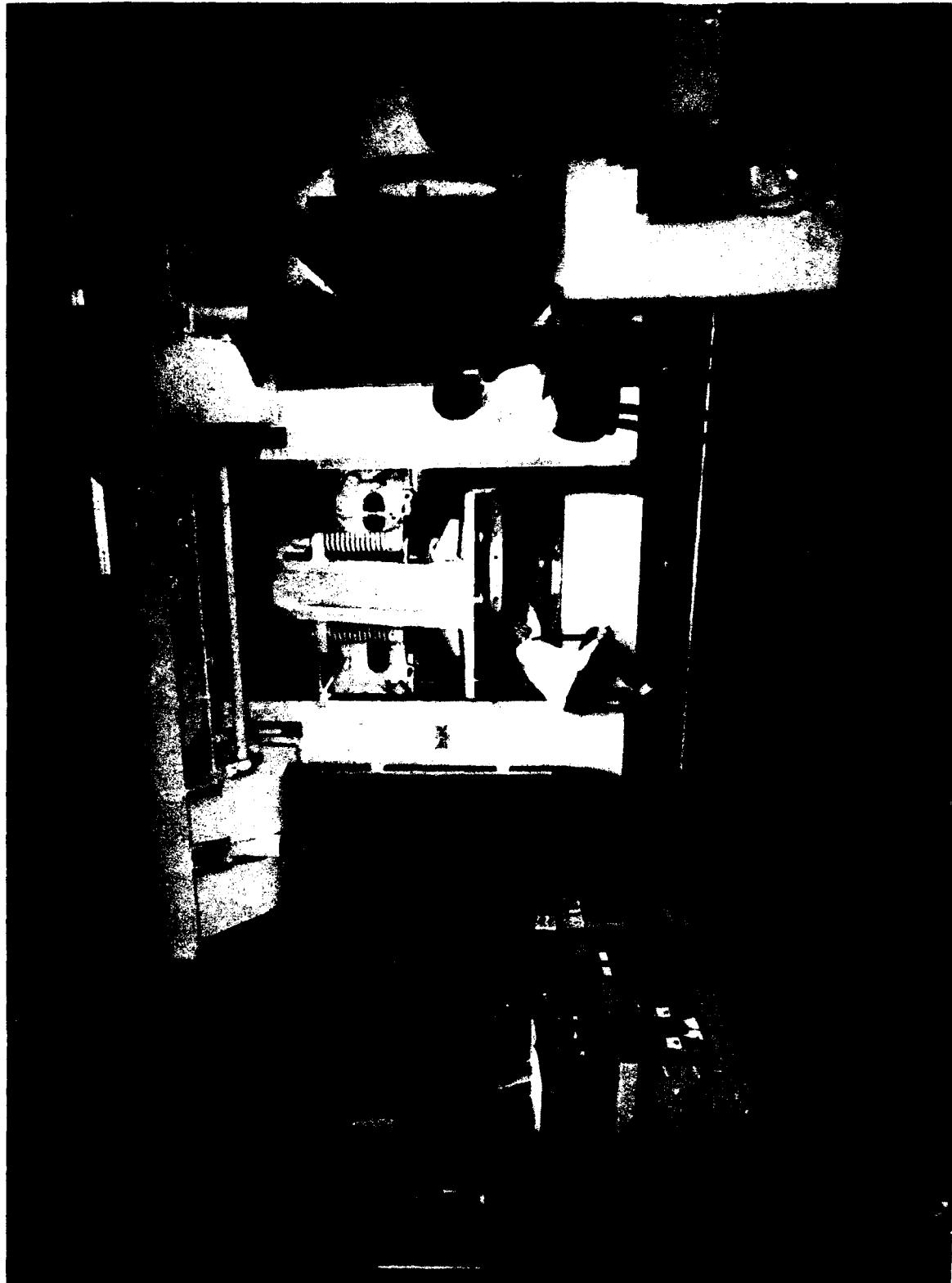




Figure 9.- Impact structures facility for studying landing characteristics of reentry vehicles. L-62-6287

L-64-5402

Figure 10.- Universal hydraulic testing machine with 1 200 000-lb capacity.



L-64-915

Figure 11.- Lunar landing facility.

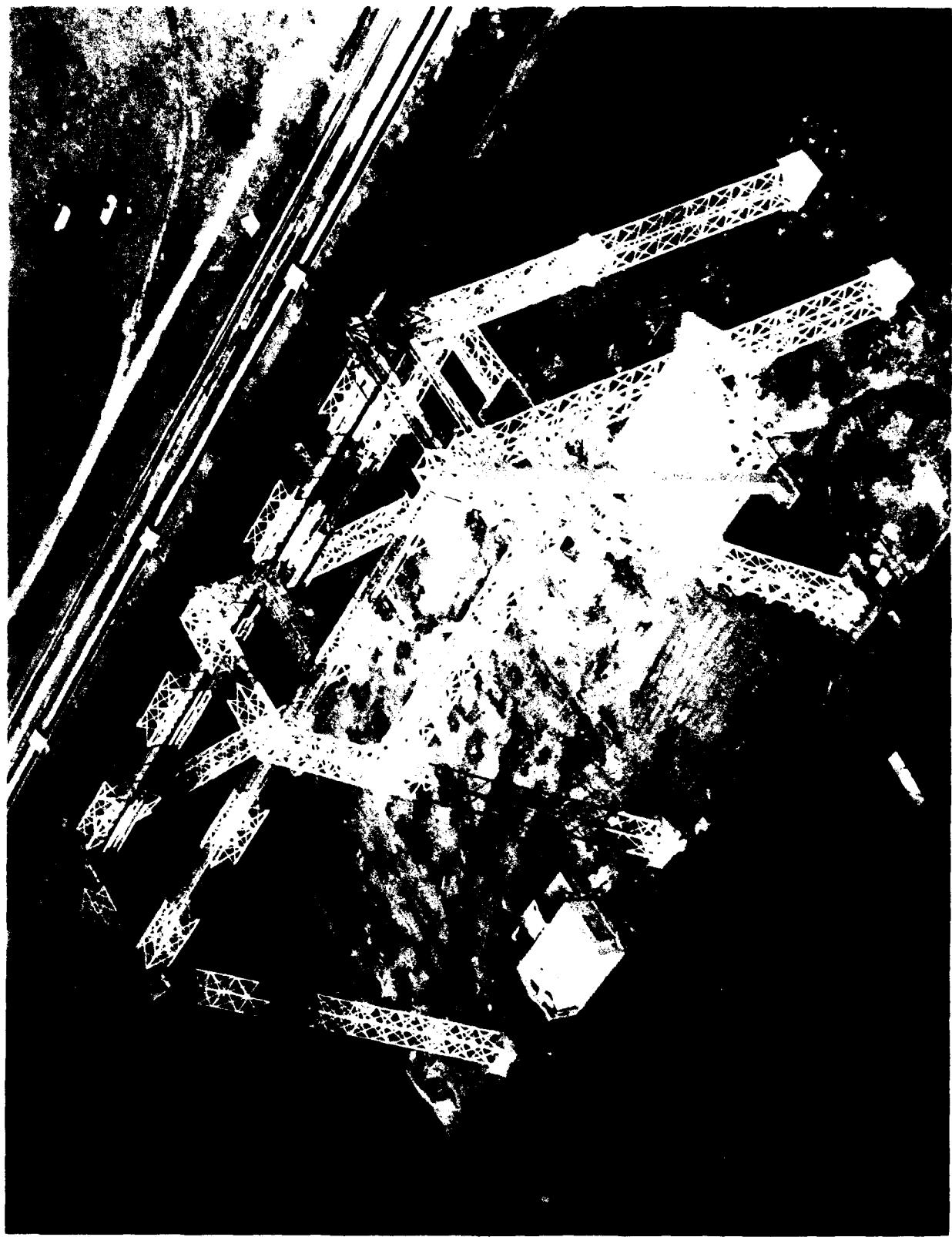




Figure 12.- Exploding foil gun.

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Figure 13.- 10 000-kilowatt radiant heating facility.

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L-65-726

Figure 14.- Carbon arc lamp for sunlight simulation.

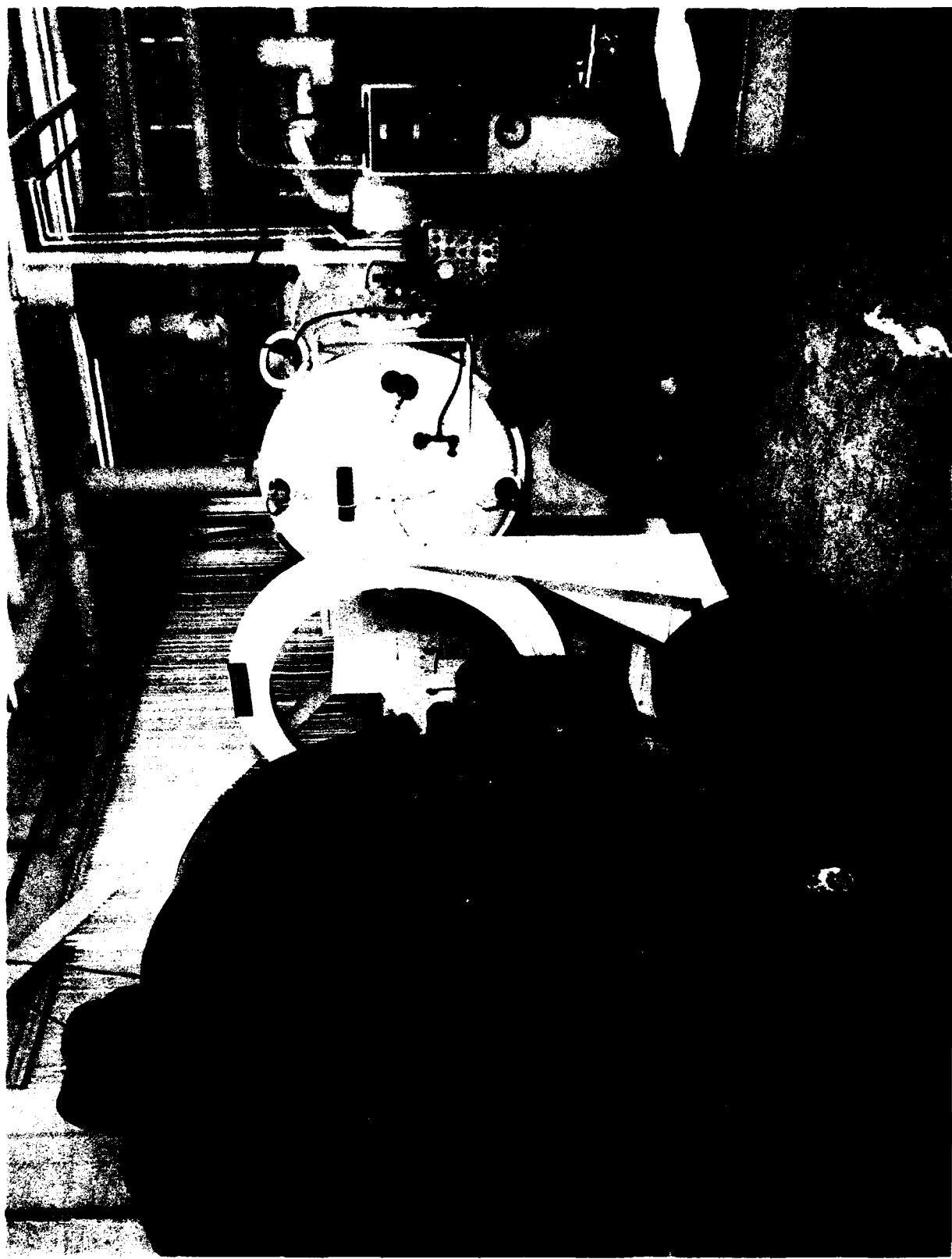




Figure 15.- Apollo model in 2500-kilowatt arc jet.

L-64-2372.1

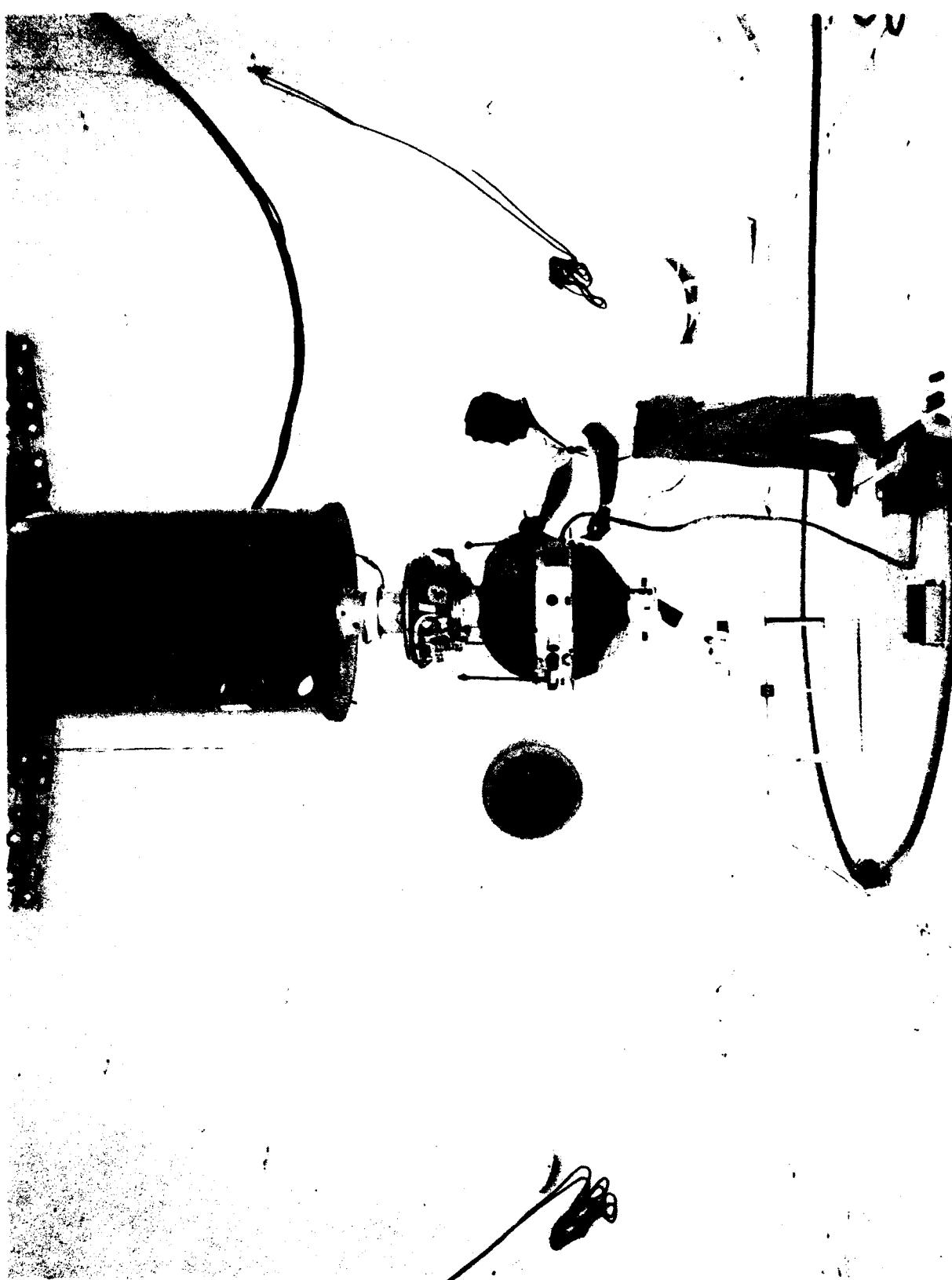


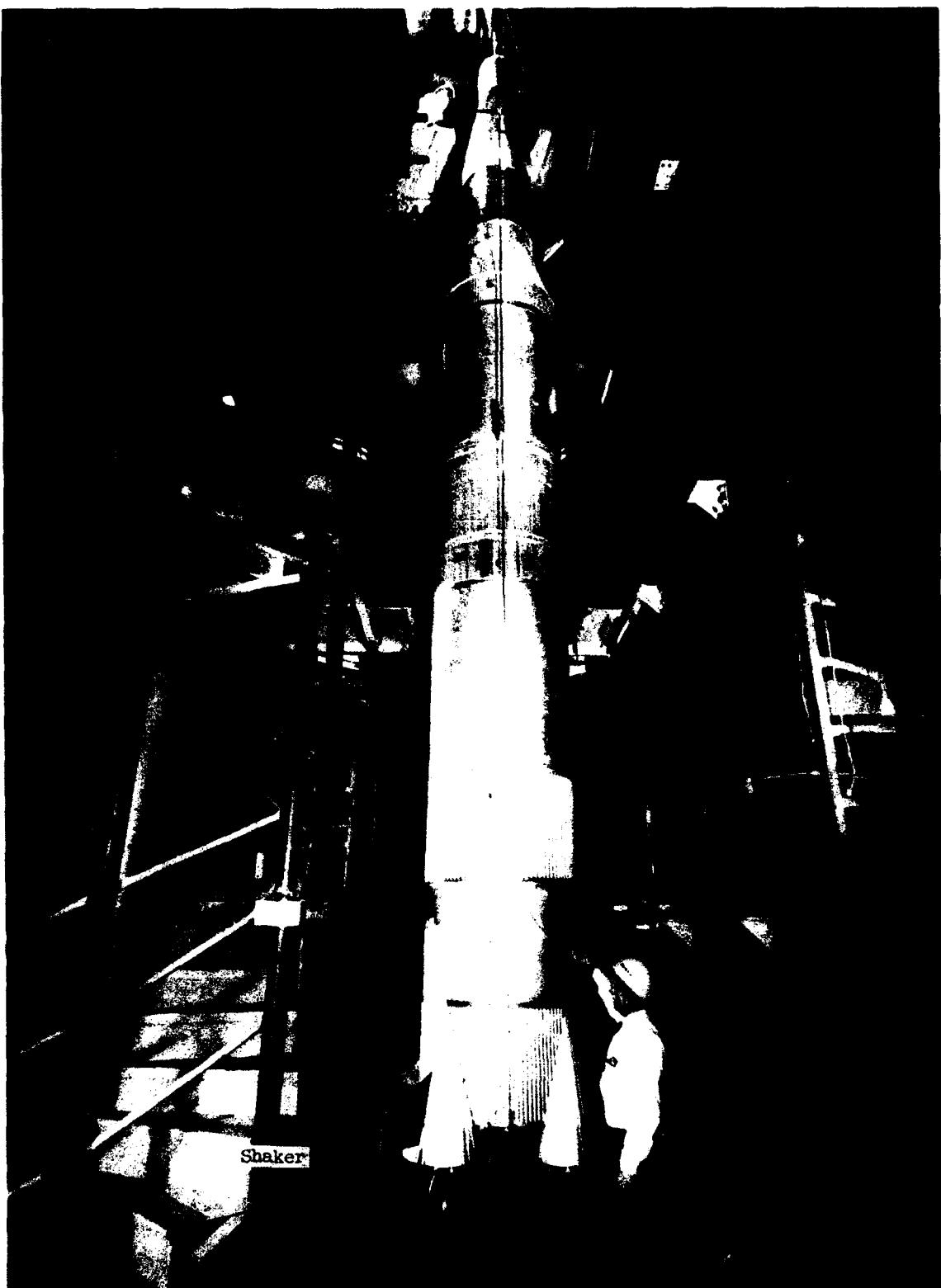
Figure 16.- Air density Injun Explorer in 60-foot vacuum sphere.

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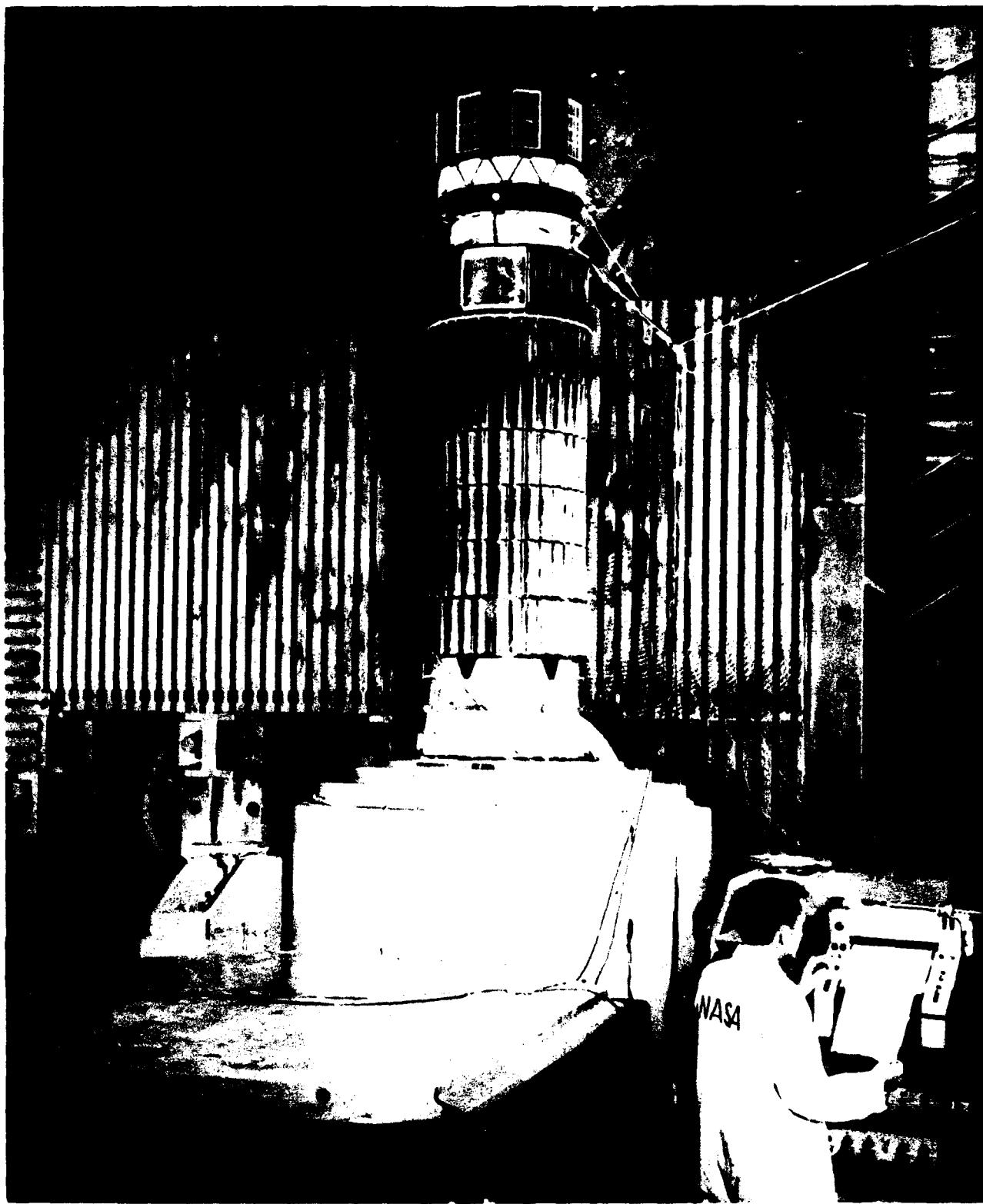
L-63-5847

Figure 17--150-cubic-foot space vacuum facility.





L-65-201
Figure 18.- One-tenth scale model of Saturn V with electromagnetic shaker attached.



L-64-2195
Figure 19.- 28 000-pound electromagnetic shaker showing micrometeoroid satellite S-55.